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A fast high voltage spark gap pulser

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A fast high voltage pulse generator built around an EFP-60, 4C35 hydrogen thyratron and a three electrode spark gap is described. The performance of the pulser and the construction of the spark gap are given.

A high voltage spark gap pulser shown in figure 1 has been developed for firing a Marx Voltage Multiplier circuit which supplies high voltage trigger

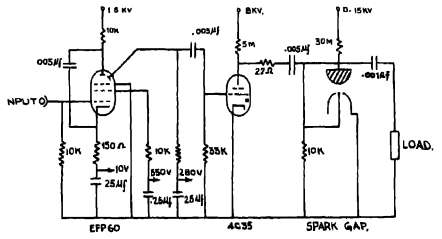


Figure 1. High voltage spark gap pulser.

pulses to a wide gap spark chamber. The input stage of the pulser consists of an EFP-60 secondary emission sharp cut-off pentode which is commonly used for its high power output and excellent pulse characteristics.

The EFP-60 tube, working here as a univibrator due to its capacitive coupling between anode and the cathode, is normally cut-off and triggers on receiving pulses of amplitude greater than 15 volts. The dynode output is a pulse of large amplitude and of sharp rise time. The oscilloscope (Tektronix 585A) record of the waveform is shown in figure 2, where the vertical sensitivity and the sweep speed used are indicated in the caption of the figure. The pulse amplitude as seen in the figure is about 800 volts and its rise time (10% to 90% rise) is about 30 nanoseconds. The pulse power is sufficient to switch the extinguished thyratron 4C35. The large pulse power is mainly due to 1.6KV applied to the plate of the tube and to rather generous cathode emission characteristics of EFP-60. The

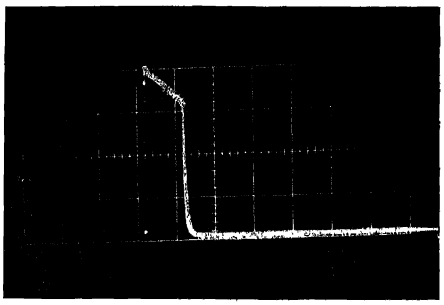
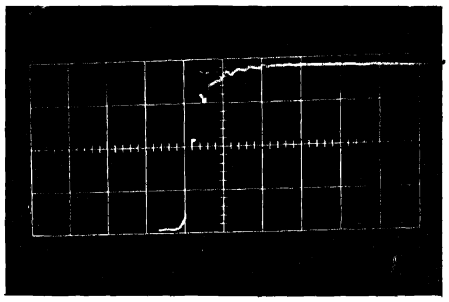


Figure 2. (a) Oscillogram showing the EFP-60 dynode output (full wave form).
Vertical ensitivity—200 volts/cm
Sweep speed—5 microsec/cm



(b) Oscillogram showing the EFP 60 dynode output leading edge of the waveform).
Vertical sensitivity—200 volts cm
Sweep speed—50 nanosec/cm

emission of secondary electrons from the sensitive surface of the dynode also contributes significantly to the pulse power.

The large grid drive used to switch the thyratron tends to decrease its switching delay which is mainly due to the firing time of the grid cathode gap of the thyratron. The overall delay of the circuit in this case is about 100 nanoseconds. This is clearly seen in the oscilloscope record of the output waveform (figure 3, upper trace), measured after attenuating the

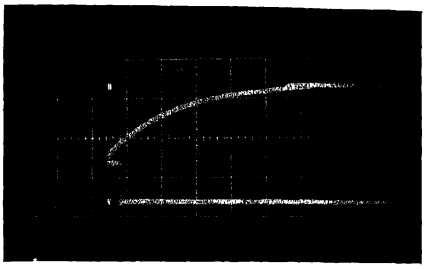
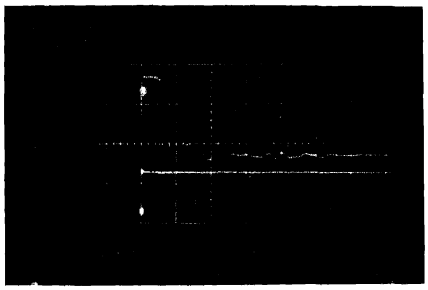


Figure 3. (a) Oscillogram showing the complete waveform.
Vertical sensitivity—5 KV/cm
(upper trace-negative output) and 20 volts/cm (lower trace positive input).
Sweep speed—10 microsec/cm.



(b) Oscillogram showing the delay time. Vertical sensitivity—as in 3 (a)
Sweep speed—100 nanoseconds/cm

pulse amplitude to 1/25th of its value by using resistance voltage divider network. The rectangular input trigger pulse is seen in the lower trace.

Other methods to reduce this delay include the increase of heater voltage (Burgov *et al* 1964) of the thyratron and the application of a positive grid bias (Korenchenko *et al* 1965). Increasing the heater voltage, however, affects the life of the thyratron adversely and positive grid bias increases the danger of accidental sparking in the thyratron due to any unknown voltage fluctuation.

The spark gap, which fires on receiving trigger pulses of 3 KV and more from the thyratron 4C35, when the spark gap high voltage electrode

is set about 500 volts below the spontantaneous sparking voltage, is described below.

The Spark Gap

The spark gap of the three electrode type which is easy to fabricate and requires only normal machining tolerances is shown in figure 4.

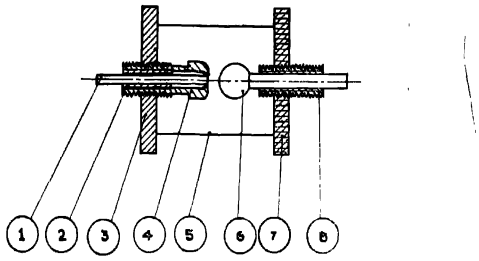


Figure 4. Sectional view of the spark gap (diagram not to scale)
(1) Trigger electrode (2) Perspex insert (3) Metal support (4) Adjustable ground electrode (5) Brass case (6) High voltage electrode (7) Perspex support (8) Perspex screw for adjusting the distance of the high voltage electrode from the ground electrode.

The trigger electrode is insulated from the ground electrode by using perspex insert. The air gap between the trigger and the ground electrode is of the order of 0.05 mm. For reliable triggering it is only necessary that the air gap at some point be less than 0.002 mm/100V of trigger pulse height. This value is 1/4th that given by Lavoie *et al* (1964) who used a barium titanate covered trigger electrode. The low value of the triggering electric field in the case of Lavoie *et al* is obviously due to the dielectric effect of barium titanate, which on account of its high dielectric constant (over 1000), increases the effect of the electric field in the adjacent air gap.

While studying the operation of the spark gap pulser it is observed that if the trigger electrode is kept flush with the ground eleetrode as done by Lavoie *et al* direct sparking takes place between the high voltage electrode and the trigger electrode. This leads to frequent failures of the pulser due to shorting of the air gap between the trigger electrode and the ground electrode by metal deposits produced in the sparking. The difficulty can be removed by blowing an air stream between the two electrodes. This has, however, been overcome simply by setting the trigger electrode a little below the upper surface of the ground electrode so that there is no

direct sparking between the trigger and the high voltage electrode. The pulser works satisfactorily in this setting and there are no frequent failures.

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